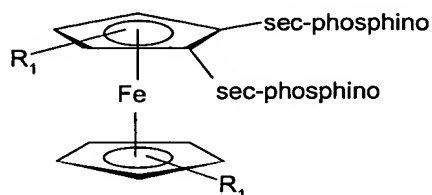


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Claims:

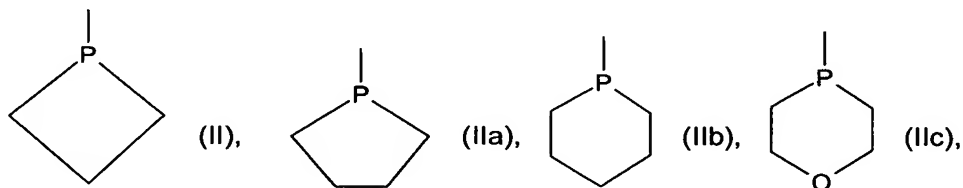
1. A compound of the formula I in the form of a racemate, a mixture of diastereomers or an essentially pure diastereomer,



where

$R_1$  is a hydrogen atom or  $C_1$ - $C_4$ -alkyl and at least one sec-phosphine group is an unsubstituted or substituted cyclic phosphino group, or a phosphonium salt thereof having one or two monovalent anions or one divalent anion.

2. The compound as claimed in claim 1, wherein the cyclic sec-phosphino corresponds to the formula II, IIa, IIb or IIc,



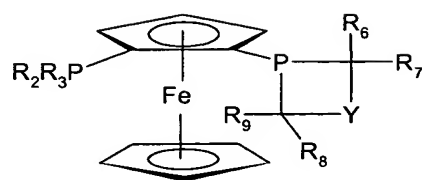
which are unsubstituted or substituted by one or more -OH,  $C_1$ - $C_8$ -alkyl,  $C_4$ - $C_8$ -cycloalkyl,  $C_1$ - $C_6$ -alkoxy,  $C_1$ - $C_4$ -alkoxy- $C_1$ - $C_4$ -alkyl, phenyl,  $C_1$ - $C_4$ -alkyl- or  $C_1$ - $C_4$ -alkoxyphenyl, benzyl,  $C_1$ - $C_4$ -alkyl- or  $C_1$ - $C_4$ -alkoxybenzyl, benzyloxy,  $C_1$ - $C_4$ -alkyl- or  $C_1$ - $C_4$ -alkoxybenzyloxy or  $C_1$ - $C_4$ -alkylidenedioxyl groups.

3. The compound as claimed in claim 2, wherein substituents are present in one or both  $\alpha$  positions relative to the P atom.

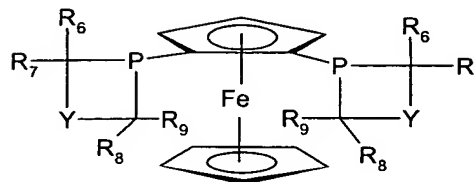
4. The compound as claimed in claim 1, wherein the compound of the formula I corresponds to the formula III or IV,

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(III),

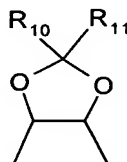


(IV),

where

$R_2$  and  $R_3$  are each, independently of one another, a hydrocarbon radical which has from 1 to 20 carbon atoms and is unsubstituted or substituted by halogen,  $C_1$ - $C_6$ -alkyl,  $C_1$ - $C_6$ -haloalkyl,  $C_1$ - $C_6$ -alkoxy,  $C_1$ - $C_6$ -haloalkoxy, di- $C_1$ - $C_4$ -alkylamino,  $(C_6H_5)_3Si$ ,  $(C_1-C_{12}\text{-alkyl})_3Si$ , or  $-CO_2-C_1-C_6\text{-alkyl}$ ,

$Y$  is  $-CH_2-$ ,  $-CH_2CH_2-$ ,  $-CH_2CH_2CH_2-$ ,  $-CH(OH)CH(OH)-$ ,  $-CH(OC_1-C_4\text{-alkyl})CH(OC_1-C_4\text{-alkyl})-$  or a radical of the formula

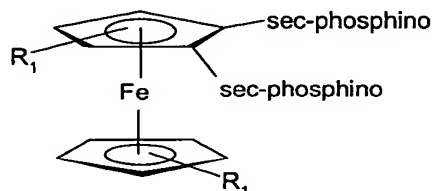


$R_6$ ,  $R_7$ ,  $R_8$  and  $R_9$  are each, independently of one another, H,  $C_1$ - $C_4$ -alkyl or benzyl, and at least one of the radicals  $R_6$ ,  $R_7$ ,  $R_8$  and  $R_9$  is  $C_1$ - $C_4$ -alkyl, benzyl or  $-CH_2-O-C_1-C_4\text{-alkyl}$  or  $-CH_2-O-C_6-C_{10}\text{-aryl}$ ,

$R_{10}$  is H or  $C_1$ - $C_4$ -alkyl and

$R_{11}$  is  $C_1$ - $C_4$ -alkyl.

5. A process for preparing compounds of the formula I in the form of racemates, mixtures of diastereomers or essentially pure diastereomers,



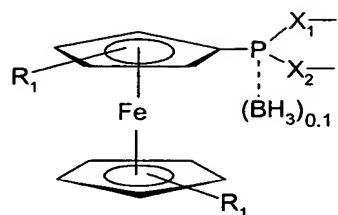
(I),

where

$R_1$  is a hydrogen atom or  $C_1$ - $C_4$ -alkyl and at least one sec-phosphino is an unsubstituted or substituted cyclic phosphino group, which comprises the steps

a) reaction of a compound of the formula V

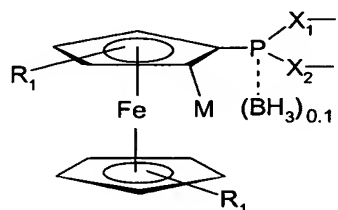
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(V),

where

$X_1$  and  $X_2$  are each, independently of one another, O or N and C-bonded hydrocarbon or heterohydrocarbon radicals are bound to the free bonds of the O and N atoms, with at least equivalent amounts of a lithium alkyl, a magnesium Grignard compound or an aliphatic Li sec-amide or  $X_3\text{Mg}$  sec-amide to form a compound of the formula VI,

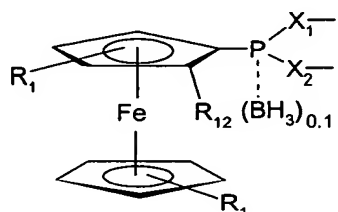


(VI),

where

M is  $-\text{Li}$  or  $-\text{MgX}_3$  and  $X_3$  is Cl, Br or I,

b) reaction of the compound of the formula VI with at least equivalent amounts of a di-sec-aminophosphine halide, a dialkoxyphosphine halide, di-sec-amino- $\text{P}(\text{O})$  halide, dialkoxy- $\text{P}(\text{O})$  halide or  $\text{PCl}_3$  or  $\text{PBr}_3$  to form a compound of the formula VII



(VII),

where

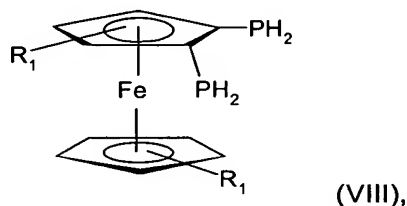
$R_{12}$  is  $-\text{PCl}_2$ ,  $-\text{PBr}_2$ ,  $\text{di}(\text{sec-amino})\text{P}-$ ,  $\text{dialkoxyP}-$ ,  $\text{di-sec-amino-P}(\text{O})-$ ,  $\text{dialkoxy-P}(\text{O})-$ , and

b1) removing any borane group present from a compound of the formula VII, then splitting off the radicals (hetero)hydrocarbon- $X_1$ , (hetero)hydrocarbon- $X_2$  or  $X_1$ -(hetero)hydrocarbon- $X_2$  or di-sec-amino or dialkoxy by means of HCl or HBr to form a  $-\text{PCl}_2$  group or  $-\text{PBr}_2$  group and then hydrogenating the  $-(\text{O})\text{PCl}_2$  groups,  $-(\text{O})\text{PBr}_2$  groups,  $-\text{PCl}_2$  groups or  $-\text{PBr}_2$  groups

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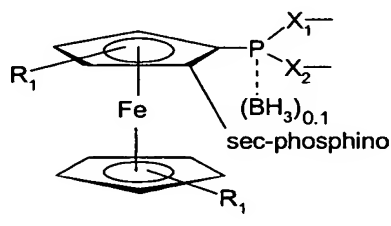
to form a compound of the formula VIII or

b2) splitting off the radicals (hetero)hydrocarbon- $X_1$ , (hetero)hydrocarbon- $X_2$  or  $X_1$ -(hetero)hydrocarbon- $X_2$  or di-sec-amino or dialkoxy from a compound of the formula VII by means of HCl or HBr to form a - $PCl_2$  group or - $PBr_2$  group and then hydrogenating the - $(O)PCl_2$  groups, - $(O)PBr_2$  groups, - $PCl_2$  groups or - $PBr_2$  groups and then removing the borane group to form a compound of the formula VIII,



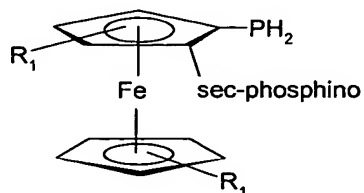
or

c) reaction of a compound of the formula VI with a sec-phosphine halide to form a compound of the formula IX,



c1) removing any borane group present from a compound of the formula IX, then splitting off the radicals (hetero)hydrocarbon- $X_1$ , (hetero)hydrocarbon- $X_2$  or  $X_1$ -(hetero)hydrocarbon- $X_2$  by means of HCl or HBr to form a - $PCl_2$  group or - $PBr_2$  group and then hydrogenating the - $PCl_2$  groups or - $PBr_2$  groups to form a compound of the formula X or

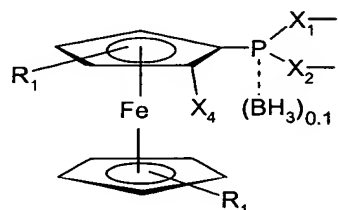
c2) splitting off the radicals (hetero)hydrocarbon- $X_1$ , (hetero)hydrocarbon- $X_2$  or  $X_1$ -(hetero)hydrocarbon- $X_2$  from a compound of the formula IX by means of HCl or HBr to form a - $PCl_2$  group or - $PBr_2$  group and then hydrogenating the - $PCl_2$  groups or - $PBr_2$  groups and then removing the borane group to form a compound of the formula X



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or

d) reaction of a compound of the formula VI with a halogenating reagent to form a compound of the formula XI

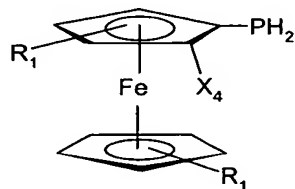


(XI),

where  $X_4$  is Cl, Br or I,

d1) removing any borane group present from a compound of the formula XI, then splitting off the radicals (hetero)hydrocarbon- $X_1$ , (hetero)hydrocarbon- $X_2$  or  $X_1$ -(hetero)hydrocarbon- $X_2$  by means of HCl or HBr to form a  $-PCl_2$  group or  $-PBr_2$  group and then hydrogenating the  $-PCl_2$  group or  $-PBr_2$  group to form a compound of the formula XII or

d2) splitting off the radicals (hetero)hydrocarbon- $X_1$ , (hetero)hydrocarbon- $X_2$  or  $X_1$ -(hetero)hydrocarbon- $X_2$  from a compound of the formula XI by means of HCl or HBr to form a  $-PCl_2$  group or  $-PBr_2$  group and then hydrogenating the  $-PCl_2$  groups or  $-PBr_2$  groups and then removing the borane group to form a compound of the formula XII



(XII)

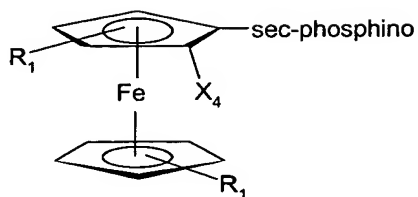
and

d3) reacting the compound of the formula XII with a metalated sec-phosphide to form a compound of the formula X,

e) reaction of the compound of the formula VII with at least 2 equivalents and of the compound of the formula X with at least 1 equivalent of a cyclic sulfate or an open-chain disulfonate to produce compounds of the formula I in which one or both sec-phosphino groups are cyclic sec-phosphino or

f) reaction of a compound of the formula XII with at least 1 equivalent of a cyclic sulfate or an open-chain disulfonate to produce compounds of the formula XIII,

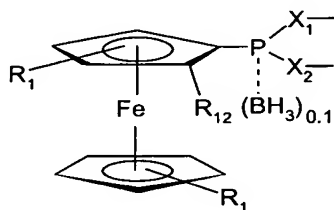
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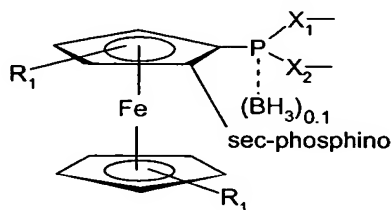
(XIII)

where sec-phosphino is cyclic sec-phosphino which may, if appropriate, be protected by BH<sub>3</sub>, and then reaction of a compound of the formula XIII with at least 1 equivalent of a lithium alkyl and then with at least 1 equivalent of a sec-phosphine halide to form a compound of the formula I.

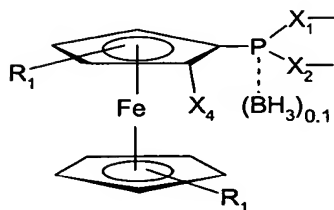
6. A compound of the formula VII, IX and XI,



(VII),



(IX), and



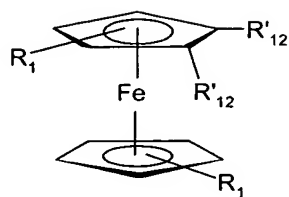
(XI),

where

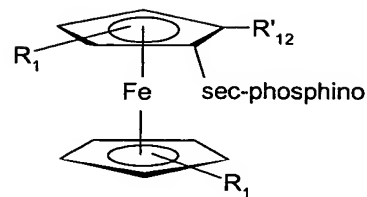
X<sub>1</sub> and X<sub>2</sub> are each, independently of one another, O or N and C-bonded hydrocarbon or heterohydrocarbon radicals are bound to the free bonds of the O and N atoms and R<sub>1</sub>, R<sub>12</sub> and X<sub>4</sub> are as defined in claim 5.

7. A compound of the formula VIII, X or XII,

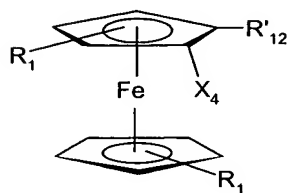
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(VIII),



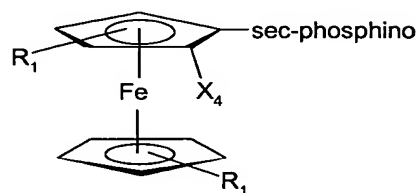
(X), and



(XII),

where  $R'_{12}$  is  $-PCl_2$ ,  $-PBr_2$  or  $-PH_2$  and  $R_1$  and  $X_4$  are as defined in claim 5.

8. A compound of the formula XIII



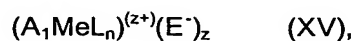
(XIII),

where  $R_1$  and  $X_4$  are as defined in claim 5 and sec-phosphino is cyclic sec-phosphino.

9. A complex of a metal selected from the group consisting of the group 8 transition metals with compounds of the formula I as ligands.

10. The metal complex as claimed in claim 9, wherein the group 8 transition metal is ruthenium, rhodium or iridium.

11. The metal complex as claimed in claim 9, characterized in that it corresponds to the formula XIV or XV,



where  $A_1$  is a compound of the formula I,

L represents identical or different monodentate, anionic or nonionic ligands, or  $L_2$  represents



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identical or different bidentate, anionic or nonionic ligands;

n is 2, 3 or 4 when L is a monodentate ligand or n is 1 or 2 when L is a bidentate ligand;

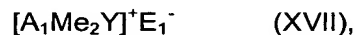
z is 1, 2 or 3;

Me is a metal selected from the group consisting of Rh, Ir and Ru; with the metal having the oxidation state 0, 1, 2, 3 or 4;

E<sup>-</sup> is the anion of an oxo acid or complex acid; and

the anionic ligands balance the charge of the oxidation state 1, 2, 3 or 4 of the metal.

12. The metal complex as claimed in claim 9, characterized in that it corresponds to the formula XIII or XIV,



where

A<sub>1</sub> is a compound of the formula I;

Me<sub>2</sub> is rhodium or iridium;

Y represents two olefins or diene;

Z is Cl, Br or I; and

E<sub>1</sub><sup>-</sup> is the anion of an oxo acid or complex acid.

13. The use of metal complexes as claimed in claim 9 as homogeneous catalysts for preparing chiral organic compounds by asymmetric addition of hydrogen, boron hydrides or silanes onto a carbon-carbon or carbon-heteroatom multiple bond in prochiral organic compounds or asymmetric addition of carbon nucleophiles or amines onto allyl compounds.

14. A process for preparing chiral organic compounds by asymmetric addition of hydrogen, boron hydrides or silanes onto a carbon-carbon or carbon-heteroatom multiple bond in prochiral organic compounds or asymmetric addition of carbon nucleophiles or amines onto allyl compounds in the presence of a catalyst, characterized in that the addition reaction is carried out in the presence of catalytic amounts of at least one metal complex as claimed in claim 9.

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